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GIBELLULA CAPILLARIS Morgan n. sp.—Stroma simple, capillary, flexuous, curved and coiled, fulvous, whitish at the summit; the base none or very short, almost the whole surface sporiferous. Hyphae longitudinal, very slender, fulvous, solidly packed together and connate, at the surface giving off very short or minute sporiferous branchlets; the sporophores thick, obtuse, pellucid, each from its apex producing several spores in one or a few short chains, which are proliferously developed. Spores clavate, smooth, hyaline, 6-9 x 1-2 mic.

Growing out of very small dead insects among the old leaves in woods; Preston, O., June 14, 1903. There are as many as a dozen growing out of one small insect, curved and coiled about it like a bundle of fine hairs. The stromata 5-8 mm. long, 40-60 mic. in thickness; the sporophores scarcely longer than the spores but much thicker.

CULTURES OF UREDINEAE IN 1904.[1]

J. C. ARTHUR.

The present article forms the fifth of a series of reports[2] by the author upon the cultures of plant rusts. They cover the years from 1899 to the present year inclusive. In these studies the grass and sedge rusts hold a prominent place, but some other heteroecious and a few autoecious rusts have been included.

During the period when the cultures are in progress, the constant attention of one person is required to assort the material which is in germinating condition from that not yet ready to germinate, to sow the spores, to maintain a careful watch for the first appearance of the spermogonia and aecidia, and to keep the records with unimpeachable accuracy. At the beginning of the present season the Indiana Experiment Station established a cooperative agreement with the Bureau of Plant Industry of the U. S. Department of Agriculture to mutually assist in carrying on the annual culture work. Through the government assistance Mr. F. D. Kern, a senior student from the University of Iowa, recommended by Professor T. H. MacBride, was secured to take charge of the cultures. Mr. Kern proved an exceptionally able man for the position, having unusually keen and accurate powers of observation, a retentive memory, and scholarly enthusiasm. Mr. Kern's work extended through May, and a part of April and June.

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[1] Read before the Botanical Society of America, Philadelphia, December 30, 1904.

[2] See Bot. Gaz. 29:268-276; Jour. Mycol. 8:51-56; Bot. Gaz. 35:10-23, and Jour. Mycol. 10:8-21.

I am under many obligations to a number of botanists, who have most kindly sent me teleutosporic material, and in some cases particular host plants on which sowings could be made. My especial thanks are extended to those who have made field observations, and provided me with clues to solve the relationship of isolated forms, the information received from Rev. J. M. Bates, and Mr. E. W. D. Holway, being particularly helpful. Further acknowledgments are made under the several species. I should further mention the kindness of Messrs. R. Douglas' Sons, of Waukegan, Ill., who sent twenty-five thrifty young larch without asking payment, as they did a year ago.

During the present season 90 collections of material were employed, and 261 drop cultures and 10 Petri dish cultures were made from them to test the germinating condition of the spores. Out of these 38 collections refused to germinate, and were consequently useless. There were in all 264 sowings of spores made, representing 40 species of rust, and for this purpose were required 119 species of hosts temporarily grown in pots in the greenhouse.

A few cultures were made with material for which no clues were obtainable to indicate the possible relationship, and in every case with negative results. The record is given here, as in previous years, to serve for future reference.

1. PUCCINIA on the leaves of *Elymus Canadensis* L., sent by Rev. Bates from Red Cloud, Neb., was sown on *Baptisia tinctoria, Polygala Senega, Uvularia perfoliata, Mimulus ringens, Symphoricarpos pauciflorus,* and *S. racemosus,* with no infection. Two other hosts were tried in 1903, with equally negative results.[3]

2. PUCCINIA on *Muhlenbergia Mexicana,* sent by Mr. E. Bartholomew from Stockton, Kans., was sown on *Hibiscus militaris,* with no infection. Similar material sent by Rev. J. M. Bates from Red Cloud, Neb., on *M. racemosa,* was sown on *Asclepias incarnata,* and twice on *Hibiscus militaris,* with no infection. What is probably the same fungus on the latter host coming from Callaway, Neb., was sown in 1902 on ten other species of hosts with equally negative results.[4] It is evident that while some of the rust found upon *Muhlenbergia* undoubtedly is associated with the aecidium on *Hibiscus,* as Professor Kellerman clearly proved last year,[5] there are other forms having entirely different aecidia, not yet ascertained.

3. PUCCINIA on *Carex Pennsylvanica,* sent by Rev. Bates from Red Cloud, Neb., was sown on *Ambrosia trifida, Polemonium reptans, Erigeron annuus, Lepidium apetalum,* and *Solidago*

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[3] Jour. Mycol. 10:10. 1904.

[4] Bot. Gaz. 35:11. 1903.

[5] Jour. Mycol. 9:109, 232. 1903.

Canadensis, with no infection. Similar material on the same species of host, gathered at Lafayette, Ind., was sown on *Oxalis violacea, Actaea alba, Macrocalyx Nyctelea, Apios Apios,* and *Solidago ulmifolia,* with no infection. What is probably the same species of rust, on the same host, was sown in 1903 on eleven other species of hosts with negative results.[6]

4. PUCCINIA on *Carex gravida,* sent by Rev. Bates from Red Cloud, Neb., was sown on *Steironema ciliatum,* with no infection. Similar material from the same source was sown in 1903 on twelve other species of hosts with negative results.[7]

5. PUCCINIA LUDIBUNDA E. & E., sent by Mr. E. Bartholomew from Stockton, Kans., was sown upon *Steironema ciliatum, Macrocalyx Nyctelea,* and *Xanthium Canadense,* with no infection.

6. PERIDERMIUM on *Pinus rigida* was sent by Professor W. A. Kellerman from Sugar Grove, Ohio, in fine quantity, with the suggestion that it would probably grow upon *Campanula.* It was sown June 1st on what were supposed to be four plants of *C. Americana,* but which proved to be *Lobelia syphilitica,* when the plants came into bloom. The plants were unusually thrifty, and conditions for success were good, but there was no infection. Part of the same collection of spores grew on *C. Americana,* when sown by Prof. Kellerman,[8] showing that they belonged to *Coleosporium Campanulae* (Pers.) Lev.

Sixteen species of rusts were successfully grown, that had been studied with success before, and reported upon by the writer and in part by other investigators. Mention of them here serves to confirm previous work, and to give some additional knowledge regarding hosts.

1. MELAMPSORA MEDUSAE Thuem.— Teleutosporic material of this species on *Populus deltoides* was obtained near Lafayette, Ind., and sown May 10 on *Larix decidua* and *Euonymus obovatus.* The latter gave no result, but the former showed spermogonia on May 25, yet owing to weakness of the hosts no aecidia formed. The same collection was used to sow on *Larix laricina* (Du R.) Koch (*L. Americana* Michx.) May 23, which showed spermogonia June 4, but the host was too weak to permit aecidia to form.

Teleutosporic material on *P. deltoides* from Spirit Lake, Iowa, by the writer was sown May 10, on *Larix decidua* and *L. laricina,* with only feeble results on the former owing to the weakness of the hosts. Another sowing was made May 23 on *L. decidua,* which gave abundance of spermogonia on May 30, and an equal abundance of aecidia on June 4.

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[6] Jour. Mycol. 10:10. 1904.
[7] Jour. Mycol. 10:10. 1904.
[8] Jour. Mycol. 11:32. 1905.

Teleutosporic material on *Populus tremuloides* Michx. was sent from Racine, Wis., by Dr. J. J. Davis, and was sown on *Larix decidua,* May 25. Abundance of well developed spermogonia appeared on June 5, followed by strongly developed aecidia on June 10. This culture is specially significant in showing that the poplar rust of North America is probably all of one species, as assumed in last year's report of cultures.[9]

2. Phragmidium speciosum Fr. has twice before been the subject of cultures, being grown in 1899[10] on a tea rose from the garden, and in 1902[11] on *Rosa humilis.* The teleutosporic material used this season was obtained by the writer at Spirit Lake, Iowa, on *Rosa Arkansana.* It was sown on *R. Arkansana* Port., *R. Carolina* L., *R. humilis* Marsh., and *R. nitida* Willd., with abundant success in each case. It was sown twice on *R. lucida* Ehrh. without success, although the host was in fine growing condition. The dates were as follows:

May 7, Teleutospores sown on *R. Arkansana;* May 14, spermogonia; May 20, aecidia.
May 7, Teleutospores sown on *R. Carolina;* May 14, spermogonia; May 18, aecidia.
May 17, Teleutospores sown on *R. humilis;* May 23, spermogonia; May 30, aecidia.
May 17, Teleutospores sown on *R. lucida;* no infection.
June 1, Teleutospores sown on *R. lucida;* no infection.
June 1, Teleutospores sown on *R. nitida;* June 8, spermogonia; June 15, aecidia.

Whether the failure to infect *R. lucida* was due to the greater mechanical resistence of the firm leaves, or to a physiological difference in the host can not be stated, but I am inclined to favor the former explanation.

3. Puccinia Helianthi Schw.— Three collections of sunflower-rust were used for cultures this season. A collection was obtained from Spirit Lake, Iowa, on *Helianthus laetiflorus,* one from Fair Oaks, in northern Indiana, on *H. mollis,* and one from Lafayette, Ind., on *H. grosse-serratus,* all by the writer. Another collection was used, but the host could not be determined with certainty, and the results are discarded. Three collections seemed to be in perfect condition, but could not be made to germinate. Forty sowings were made from the three collections used, and as a large space would be required to report the full data, the results will be given in tabular form. In this table decided and complete results are shown by an exclamation point, infection which was meager, grew slowly and gave no aecidia or very few, is shown by a semicolon, a sowing which gave no infection is indicated by a single period, and where no sowings were made a dash is used. Fifteen

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[9] Jour. Mycol. 10:13. 1904.
[10] Bot. Gaz. 29:271. 1900.
[11] Bot. Gaz. 35:17. 1903.

species of *Helianthus* were employed, on which to sow the teleutospores.

CULTURES OF HELIANTHUS RUST.

Hosts for cultures	Source of teleutosporic material		
	H. mollis	H. grosse-serratus	H. laetiflorus
1. H. annuus	!	!	!
2. H. decapetalus	–	.	–
3. H. divaricatus	–	–	;
4. H. grosse–serratus	.	!	.
5. H. hirsutus	;	.	.
6. H. Kellermani	.	–	;
7. H. laetiflorus	.	.	!
8. H. Maximiliani	.	.	–
9. H. mollis	!	.	;
10. H. occidentalis	;	.	;
11. H. orgyalis	.	.	.
12. H. scaberrimus	.	.	!
13. H. strumosus	;	.	.
14. H. tomentosus	;	;	;
15. H. tuberosus	.	.	.

! Abundant infection.
; Infection, but slow growth and few or no aecidia formed.
. No infection.
– Not sown.

The results of this year accord closely with those of 1902 and 1903. In 1902 some success was attained in sowing spores from *H. grosse-serratus* on *H. Maximiliani*, but no success this year. In 1903 sowing spores from *H. mollis* on *H. strumosus* gave no infection, this year a few spermogonia were formed, but no further development took place. In all other respects the work of the three years is in perfect accord. Altogether sixty-four sowings have been made.

Looking over the accompanying table it will be seen that each set of spores grew upon the species of host from which derived, but not upon the other two species, except that spores from *H. laetiflorus* sown on *H. mollis* gave a tardy showing of spermogonia, without further development. Also each set of spores grew luxuriantly upon *H. annuus*, and each made a feeble growth upon *H. tomentosus*, but on all other species they either failed to infect or made a feeble growth, with the single exception that spores from *H. laetiflorus* grew well on *H. scaberrimus*.

From all results so far available, it seems that the following conclusion may safely be drawn. *Puccinia Helianthi* Schw. is a single species, having many races, for which *H. annuus* acts as a bridging host.

4. PUCCINIA SUBNITENS Diet.—Teleutosporic material of this species on *Distichlis spicata* (L.) Greene was sent from Nebraska by Rev. J. M. Bates, to whom I am also indebted for suggestions which led to one of the most interesting series of cultures yet made. In a communication dated April 30, 1904,

Rev. Bates says: "Last spring I found *Æcidium* on *Cleome serrulata* in two nearby localities, and on *Chenopodium album,* closely associated with the rust on *Distichlis spicata,* and no other. Now I have it again under same conditions. I wrote Mr. Holway about it and shocked him; he does not think it possible. But I am well convinced that it is the same as on Chenopodium" [proved by cultures in 1902 from Distichlis-rust sent by Rev. Bates]. Further reasons were given for believing that the *Cleome* and *Chenopodium* aecidia came from teleutospores on *Distichlis,* among them being that "last year I watched for the uredo from it on the *Distichlis,* and got it May 21, after collecting the first *Cleome* aecidia May 5." All these observations seemed very convincing, yet the deductions seemed very improbable. He followed up the statements by sending seedling plants of *Cleome serrulata* and *Chenopodium album* on which the large, brilliant orange-colored aecidia occurred in remarkable profusion, and so much alike that in appearance and structure they had to be pronounced identical. As the season progressed Rev. Bates also sent freshly collected specimens of aecidia on *Roripa sinuata* (Nutt.) Hitch., *Sophia incisa* (Engelm.) Greene, and *Salsola Tragus* L., which he considered belonged to the same inclusive species. The results of my cultures confirm the above clever observations, and add still other hosts for the aecidium. The data are as follows:

May 17, Sown on *Chenopodium album;* May 25, spermogonia; June 5, aecidia.
May 17, Sown on *Cleome spinosa;* May 25, spermogonia; May 30, aecidia.
May 17, Sown on *Lepidium apetalum;* May 25, spermogonia; June 7, aecidia.
May 30, Sown on *Lepidium Virginicum;* June 7, spermogonia; June 16, aecidia.
May 30, Sown on *Sophia incisa;* June 7, spermogonia; plant injured.
May 30, Sown on *Erysimum asperum;* June 5, spermogonia; June 14, aecidia.
May 30, Sown on *Cleome spinosa;* June 5, spermogonia; June 14, aecidia.

We have here a demonstration of the remarkable fact, not known for any other species of rust so far as I recall, that *Puccinia subnitens* with teleutospores on *Distichlis spicata* has aecidia growing with equal vigor upon species belonging to three families of plants. The teleutospores for the above sowings were all taken from the same collection, and from only a few leaves of the grass, which precludes the possibility of a differentiation in the teleutoform, or any division into races. The aecidium is unusually well marked. Going over my herbarium and taking out the forms which are identical with this species, beyond a doubt, and adding to those already mentioned, we have the following hosts and distribution for the aecidium of this species.

Puccinia subnitens Diet.

On Chenopodiaceae:
Chenopodium album L. Montana, New Mexico, Nebraska.
Chenopodium leptophyllum (Moq.) Nutt. Nebraska.
Chenopodium glaucum L. Montana.
Salsola Tragus L. Nebraska.

On Capparidaceae:
Cleome serrulata Pursh. Nebraska, Montana.
Cleomella parviflora A. Gr. Nevada.

On Cruciferae:
Lepidium apetalum Willd. Nebraska, Montana.
Roripa sinuata (Nutt.) Hitch. Nebraska.
Sophia incisa (Engelm.) Greene. Nebraska.
Stanleya pinnata (Pursh.) Britt. Colorado.

5. PUCCINIA PANICI Diet.— The connection of this rust with *Æcidium Pammelii* Trel. on *Euphorbia corollata* L. was reported by William Stuart[12] based on somewhat meager but seemingly convincing cultures made in 1901. Teleutosporic material for the present trial was obtained at Fair Oaks, Ind., on *Panicum virgatum.* It was sown on *Euphorbia corollata* May 16, and again May 24, and both sowings showed the most abundant results, giving the first spermogonia respectively on May 24 and June 1, and aecidia May 30 and June 9. There can be no doubt that these two forms are members of one species. While at Lafayette the rust is very rare, at Fair oaks it is exceedingly abundant on both the *Panicum* and the *Euphorbia.* It is one of the few glumaceous rusts observed by the writer, having so nearly an equal display of both the aecidial and teleutosporic forms. The aecidial form having first been published, requires the name to be written PUCCINIA PAMMELII (Trel.) nom. nov.

6. PUCCINIA VERBENICOLA (E. & K.) Arth.— Previous cultures[13] with this species were verified by sowing teleutospores, from *Sporobolus longifolius* sent by Rev. J. M. Bates from Red Cloud, Neb., on *Verbena urticaefolia,* May 16, resulting in spermogonia May 23 and aecidia May 30. Also another successful culture was made with similar material sent by Mr. E. Bartholomew from Stockton, Kans., sown on *V. urticaefolia* June 3, showing spermogonia June 11, and aecidia June 18.

7. PUCCINIA WINDSORIAE Schw. — Teleutospores from *Tricuspis seslerioides* Torr., Lafayette, Ind., were sown May 19, on *Ptelea trifoliata* and *Xanthoxylum Americanum,* both members of the family *Rutaceae,* and both known to be hosts to an aecidium. Although the conditions were exceptionally favorable, no infection resulted on *Xanthoxylum,* while *Ptelea*

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[12] Proc. Ind. Acad. Sci. for 1901:284. 1902.
[13] Bot. Gaz. 29:274. 1900, and 35:16. 1903.

gave spermogonia May 25, and aecidia May 31, in accordance with results heretofore obtained.[14]

8. PUCCINIA FRAXINATA (Schw.) Arth.— Cultures of this species were successfully carried out in 1899,[15] showing that the aecidium occurs upon *Fraxinus.* As similar aecidia have been collected upon *Ligustrum vulgare* L., in New York, and *Adelia segregata* (Jacq.) Small (*Forestiera porulosa* Poir.) in Florida,[16] members of the family *Oleaceae,* to which *Fraxinus* belongs, a number of trials were made to see if the number of hosts could be extended. Teleutosporic material was obtained at Spirit Lake, Iowa, on *Spartina cynosuroides.* Sowings were made on *Ligustrum vulgare* (2), *Ligustrum ovalifolium* (2), *Syringa vulgaris* (2), *Chionanthus Virginica* (2), *Adelia acuminata, Adelia ligustrina,* and *Fraxinus lanceolata,* all members of the family Oleaceae, yet no infection took place except on the last host. Although the conditions for success were seemingly excellent, still I am not fully convinced that some of these failures were not due to accident. I am under obligation to Dr. George V. Nash, of the N. Y. Bot. Garden, for a plant of *Adelia acuminata,* sent from the Garden for this culture work.

9. PUCCINIA IMPATIENTIS (Schw.) Arth.— Teleutosporic material on *Elymus Virginicus* was sent from Racine, Wis., by Dr. J. J. Davis, and sown May 7, on *Clematis Virginiana* and *Impatiens aurea.* The first gave no infection, the second showed spermogonia May 14, and aecidia May 23.[17]

10. PUCCINIA POCULIFORMIS (Jacq.) Wettst. — Teleutosporic material was found at Spirit Lake, Iowa, on *Elymus Canadensis* L., and without a careful examination was sown on *Clematis Virginiana* (2), *C. Scottii, Cimicifuga Americana, C. racemosa, Actaea alba,* and *Impatiens aurea,* with no infection. A microscopic study revealed the nature of the rust, and it was sown upon *Berberis vulgaris* May 18, with abundant infection, spermogonia appearing May 25, and aecidia duly following, but not recorded until June 9. Teleutosporic material was also found at Spirit Lake, Iowa, on *Agropyron tenerum,* and was sown on *Berberis vulgaris* May 10, giving an abundant infection, first showing spermogonia May 17, followed in due time by aecidia. Teleutosporic material on *Agropyron repens* was sent from Burlington, Vt., by Mr. William Stuart, and sown on *Berberis vulgaris* May 11. Spermogonia appeared May 18, but the leaves were injured before aecidia developed.

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[14] Bot. Gaz. 29:273. 1900, and 35:16. 1903.

[15] Bot. Gaz. 29:275. 1900.

[16] Specimen in herbarium of N. Y. Bot. Garden, and cited by Sydow, Monog. Ured. 1:808, under the erroneous name *F. "paludosa".*

[17] For previous cultures see Bot. Gaz. 35:18. 1903, and Jour. Mycol. 10:11. 1904.

11. PUCCINIA RHAMNI (Pers.) Wettst. — A number of bushes grow in the garden near the laboratory of *Rhamnus lanceolata, R. Caroliniana,* and *R. Cathartica,* on which aecidia appeared this season, not very plentifully, but in about equal abundance. Seedlings of *Avena sativa* were infected from all three sources. Æcidiospores were sown from *R. lanceolata* May 15, from *R. Caroliniana* May 19, and from *R. Cathartica* May 20. In each case uredospores appeared in abundance in about a week, the exact date not being recorded.

12. PUCCINIA ANGUSTATA Peck.— Teleutospores gathered on *Scirpus atrovirens,* Lafayette, Ind., were sown May 12, on *Lycopus Americanus,* giving spermogonia May 20, and aecidia May 27, further confirming previous cultures.[18]

13. PUCCINIA PECKII (DeT.) Kellerm.— Successful sowings[19] of teleutospores from undetermined species of *Carex* were made on *Onagra biennis,* from material sent by Rev. J. M. Bates of Red Cloud, Neb., and by Dr. J. J. Davis of Racine, Wis. A sowing was also made, May 20, on *O. biennis,* from material on *C. lanuginosa* sent by Rev. Bates from Red Cloud, Neb., which gave spermogonia May 29, and aecidia June 5. The same material was sown on *Urtica gracilis* twice without success. This gives a new host for the fungus.

Teleutosporic material on *Carex trichocarpa* from the type locality of *Puccinia Bolleyana,* was sown May 6, on *Onagra biennis* and *Sambucus Canadensis,* producing infection on both hosts, and thus repeating the experience of 1902.[20] The *Carex* bore teleutospores of both *P. Peckii* and *P. Sambuci* (Schw.) Arth. intermixed, as was easily verified by microscopic examination.

14. PUCCINIA CARICIS-ERIGERONTIS Arth.— Teleutospores gathered at Lafayette, Ind., on *Carex festucacea* were sown on *Erigeron annuus,* May 12, giving heavy infection of spermogonia May 20, and of aecidia May 27. Similar material on the same host, sent by Rev. Bates from Red Cloud, Neb., was sown May 25, on *E. annuus,* and gave spermogonia June 2, and aecidia June 9. These results confirm previous work.[21]

15. PUCCINIA ALBIPERIDIA Arth. While the conviction is gaining ground that the aecidium of this species is the common aecidium on gooseberries, yet the excellent results of this year do not give any particular support to the view. All the aecidia grown in cultures were small and pale, and apparently

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[18] Bot. Gaz. 29:273. 1900, and Jour. Mycol. 8:53. 1902.

[19] For previous cultures see Jour. Mycol. 8:55. 1902, and Bot. Gaz. 35:13. 1903.

[20] Bot. Gaz. 35:14. 1903.

[21] Jour. Mycol. 8:53. 1902, and Bot. Gaz. 35:15. 1903.

dissimilar to the bright orange-yellow aecidia on *Ribes* in the fields.

Teleutosporic material was sent by Dr. J. J. Davis from Racine, Wis., on *Carex gracillima,* which was sown on *Ribes floridum* (3), *R. rubrum,* and *R. aureum* (2), with no infection, except that in one case a few spermogonia appeared on *R. aureum* after eleven days, but reached no further development. It was also sown with abundant success on *R. Uva-crispa* (2), *R. Cynosbati* and *R. rotundifolium* (2), thus confirming previous work.[22]

Excellent teleutosporic material was found on *Carex crinita* Lam., Lafayette, Ind., and sown May 7, on *Ribes rubrum,* with no infection, on *R. Uva-crispa,* with weak infection, the plant being in poor condition, and on *R. rotundifolium* with strong infection, showing spermogonia May 17, and aecidia May 25. Another equally strong infection was secured with a sowing on the last host June 3. This culture adds another teleutosporic host.

16. PUCCINIA POLYGONI-AMPHIBII Pers. In previous years[23] this rust was sown upon three species of *Polygonum* and *Cicuta maculata* with no infection. After learning of Dr. Tranzschel's successful cultures on two European species of wild geranium[24] considerable effort was made to secure teleutosporic material with which to repeat the work. No rust could be found about Lafayette where it usually occurred. At Spirit Lake, Iowa, a diligent search where it had previously been common, only gave a few slightly rusted leaves. No better success was met with at Fair Oaks, Ind. An appeal to my excellent coadjutors, Prof. W. A. Kellerman, Columbus, Ohio, Rev. J. M. Bates, Red Cloud, Neb., and Dr. J. J. Davis, Racine, Wis., brought out the same experience, and only added a few slightly rusted leaves from Wisconsin. The three meager collections were, however, useless, as none of the teleutospores would germinate. I then waited for aecidia to appear on geranium and found them as rare as the teleutospores had been. Finally I obtained a few belated aecidia on *Geranium maculatum* L. (*AE. sanguinolentum* Lindl.) and sowed them on *Polygonum emersum* (Michx.) Britt., June 11, and on June 19, uredospores appeared, and eventually on Aug. 17, teleutospores began to form, the plants being kept in the greenhouse during the culture. The American and European forms are therefore identical.

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[22] Jour. Mycol. 8:53. 1902, and 10:11. 1904.

[23] Bot. Gaz. 35:12. 1903, and Jour. Mycol. 10:9. 1904.

[24] Centr. f. Bakt. 11^2:106. 1903.

In addition to the foregoing results five species of rusts were grown, establishing aecidial and teleutosporic connections, not heretofore recorded. The species are heteroecious with one exception.

1. MELAMPSORA BIGELOWII Thüm. — Three collections of teleutospores on *Salix* were secured, but only one, which was obtained at Racine, Wis., on *Salix amygdaloides* Anders., and forwarded by Dr. J. J. Davis, could be made to germinate. This was sown, May 10, on *Larix decidua* Mill., and twenty days later both spermogonia and aecidia were observed in abundance, although they had probably first made their appearance some days earlier. On the same date it was sown on *Euonymus obovatus* without result. A further sowing on *Larix decidua* was made on May 25, and on June 4 spermogonia began to appear in great abundance, followed on June 10 by an equal abundance of aecidia. The aecidia are of the typical caeoma-form, and are very similar to those of *Melampsora Medusae*, the chief difference being in the spores, which are somewhat more distinctly and coarsely verrucose than in the poplar form.

The only American collections of aecidia on *Larix*, that have come to my attention, were made by E. W. D. Holway at Mt. Temple, Aug. 22, 1902, and Laggan, Aug. 23, 1902, both places in Alberta, Canada, and both collections on *Larix Lyallii* Parl. These collections agree perfectly with the aecidia raised in cultures. A comparison of the numerous collections of willow rust in my own herbarium, numbering 80 packets, and representing all sections of the United States and Canada from the Atlantic to the Pacific, shows that both the uredosporic and teleutosporic stages agree closely with one another, and with those on the material used in the culture.

A comparison with European collections shows the American form to be very different from any European species. The nearest approach to the American form is *Melampsora Larici-epitea* Kleb., the most common willow rust of Europe. The two differ, however, in a very marked way. The American form has all three sorts of spores considerably larger, the spores of the aecidia and uredo have walls twice as thick, the pores are far more evident, and the papillae on the surface are much closer together.

The name which I have adopted for this common willow rust was given by Baron von Thuemen to a collection made in California on *Salix Bigelowii*, which he stated had been received from the herbarium of Dr. W. G. Farlow. Von Thuemen's herbarium was burned some years ago, and the type is consequently destroyed. In reply to an inquiry regarding the matter, Dr. Farlow states that he does not recall sending such a specimen to von Thuemen, and is unable to find a corresponding specimen in his herbarium, unless one from Santa Cruz, Calif., collected by Dr. C. L. Anderson, November, 1875, could be the one intended. This specimen, however, is said to be upon *Salix brachystachys.*

Although the type collection can not be accurately identified or duplicated, there seems to be no reason to question the reference of the fungus described to the common willow rust growing throughout California and the other parts of North America. Dr. Farlow kindly sent me a part of his specimen on *S. brachystachys,* and also a specimen on *S. Bigelowii,* collected in Washington by C. V. Piper in 1899, and they agree in all essential particulars with the eastern collections on willow.

I have also had the privilege, through the kindness of Mr. Chas. H. Peck, of examining the type specimen of *Lecythea macrosora* Pk. (Bot. Gaz. 5:35. 1880), collected in Colorado by Brandegee, and thought to be on *Epiliobium,* and find that it is the uredostage of this same species of willow rust. An examination of type material of *Melampsora paradoxa* D. & H. shows no important deviation from the common form. The peculiar free teleutospores figured by Dr. Dietel (Hedw. Beibl. 40:33. 1901) appear to be occasional reversional forms, due to disturbed nutrition or some such cause. Similar isolated teleutospores have been described by Klebahn in European material (Ztschr. f. Pf.-Kr. 9:98). The name, *Melampsora maculosa* D. & H., is *nomen nudum.* It was applied to forms showing especially bright yellow discoloration of the leaf about the uredosori, but without other marked characters, as examination of type material shows.

The species may be characterized as follows:

MELAMPSORA BIGELOWII Thuem.

0. Spermogonia amphigenous, scattered, or somewhat gregarious, minute, punctiform, pale yellow, inconspicuous, subcuticular, conical, 60–80 μ in diameter, 40–45 μ high.

I. Aecidia chiefly hypophyllous, scattered or somewhat gregarious, small, .1–.2 mm. across, oblong, pale yellow fading to white, inconspicuous, formed between the epidermis and mesophyll, soon naked, pulverulent; aecidiospores globoid, 15–22 by 18–27 μ; wall colorless, 2–3 μ thick, finely and evenly verrucose, with distinct papillae, pores scattered, noticeable.

On *Larix Lyallii* Parl., Alberta, Can., and probably on other species of *Larix* in various parts of the United States and Canada. Cultivated on *L. decidua* Mill. and *L. laricina* (DuR.) Koch.

II. Uredosori chiefly hypophyllous, usually on conspicuous yellow spots, scattered or gregarious, round, .3–.5 mm. across, orange-yellow fading to pale yellow, soon naked, somewhat pulverulent; uredospores globoid, 15–19 by 17–24 μ, wall colorless, 2.5–3.5 μ thick, sparsely and evenly verrucose, pores scattered, noticeable; paraphyses intermixed with the spores, capitate, smooth, 50–70 μ long, heads 22–25 μ broad, wall 3–5 μ thick, peripheral paraphyses thinner walled and more clavate.

III. Teleutosori amphigenous, or sometimes partly or wholly epiphyllous or hypophyllous, scattered, roundish or irregular, about .5 mm. across, often confluent, orange-yellow becoming yellowish or purplish brown, subepidermal; teleutospores prismatic or oblong, 11–14 by 29–42 μ, rounded at both ends; wall cinnamon-brown, smooth, uniformly 1 μ thick.

On *Salix amygdaloides* Anders., and many other species of Salix, throughout the United States and Canada.

Beside this common willow rust, another is known to occur on *Salix herbacea* L. in Greenland and on Mt. Washington, N. H., *Melampsora artica* Rostr. One other, *Melampsora repentis* Plowr., on *Salix repens* has been reported from North America, but has not been seen by the writer.

2. PUCCINIA TOMIPARA Trel. — I am indebted to Mr. E. W. D. Holway for the suggestion, which led to the certain demonstration of the aecidial connection for this species. Mr. Holway's observations were made in the field, and showed such close association of the recently germinated teleutospores on over-wintered leaves of *Bromus ciliatus* and the appearing aecidia on *Clematis Virginiana,* that the conclusion seemed foregone. His direct observations extended over two seasons. Teleutosporic material gathered by Mr. Holway at Decorah, Iowa, was sown on *Impatiens aurea, Dirca palustris, Clematis Virginiana, C. Fremontii, C. Scottii, C. Viorna,* and with no infection except on *Clematis Virginiana.* Teleutosporic material of *Bromus ciliatus* was kindly sent by Dr. J. J. Davis from Kenosha Co., Wis., and sown on *Clematis Virginiana* with most abundant infection. Material was also used, obtained near Lafayette, Ind., on *Bromus ciliatus,* and sown on *Dirca palustris* and *Clematis Virginiana* with no infection of the former and the most plentiful infection of the latter. The record of dates is as follows:

May 12, Teleutospores (Iowa) sown on *Impatiens aurea;* no infection.
May 12, Teleutospores (Iowa) sown on *Dirca palustris;* no infection.
May 12, Teleutospores (Iowa) sown on *Clematis Scottii;* no infection.
May 12, Teleutospores (Iowa) sown on *Clematis Fremontii;* no infection.
May 12, Teleutospores (Iowa) sown on *Clematis Virginiana;* May 19, spermogonia; May 28, aecidia.
May 18, Teleutospores (Ind.) sown on *Dirca palustris;* no infection.
May 25, Teleutospores (Iowa) sown on *Clematis Scottii;* no infection.
May 25, Teleutospores (Iowa) sown on *Clematis Fremontii;* no infection.
May 25, Teleutospores (Iowa) sown on *Clematis Viorna;* no infectiop.
May 25, Teleutospores (Iowa) sown on *Clematis Virginiana;* May 31, spermogonia; June 9, aecidia.
May 30, Teleutospores (Ind.) sown on *Dirca palustris;* no infection.
May 30, Teleutospores (Ind.) sown on *Clematis Virginiana;* June 7, spermogonia; June 15, aecidia.
June 3, Teleutospores (Wis.) sown on *Clematis Virginiana;* June 9, spermogonia; June 16, aecidia.

This record shows that the report made last year, connecting the teleutosporic stage on *Bromus ciliatus* with the aecidium on *Dirca palustris*[25] was a mistake. The teleutosporic material from Lafayette, which grew so abundantly on *Clematis Virginiana* this year, came from the same plants that were mentioned as bearing teleutospores a year ago, and standing near aecidium-laden bushes of *Dirca palustris.* Last year's supposed results, which were based on a single sowing of aecidiospores, can be explained by supposing that the *Bromus* plants were already infected when brought into the laboratory. The above plentiful data show no escape from the conclusion that the common *Bromus* rust belongs to the aecidium on *Clematis Virginiana,* and *not* to the aecidium on *Dirca palustris.* The name *Puccinia hydnoidea* (B. & C.) Arth., therefore, does not belong to the *Bromus* rust, but to some teleutosporic form not yet identified. The descriptions of uredospores and teleutospores given at the place cited belong to *Puccinia tomipara* Trel.

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[25] Jour. Mycol. 10:19. 1904.

There are at least three species of aecidia found upon *Clematis* in the United States. *Aecidium occidentale* Arth. occurs on *C. Douglasii* in the northwestern region; its teleutosporic connection is not known. *Aecidium Clematidis* DC., found on *C. ligusticifolia, C. Scottii, C. Fremontii, C. Drummondii, C. lasiantha* and *C. Viorna,* ranging from Iowa to Montana and southwestward to the Pacific coast, is the first stage of *Puccinnia Agropyri* E. & E. The third species is *Aecidium Clematitis* Schw., the one under consideration, found on *C. Virginiana,* ranging throughout the United States and Canada east of the Rocky mountains, and belongs to *Puccinia tomipara* Trel. It has larger spermogonia, and somewhat smaller aecidia and aecidiospores than that of *P. Agropyri.* It may be characterized as follows:

AECIDIUM CLEMATITIS Schw.

0. Spermogonia epiphyllous, in small groups, honey-yellow, punctiform, subepidermal, globose, 90–140 μ in diameter; ostiolar filaments 40–60 μ long.

I. Aecidia hypophyllous, in orbicular groups, crowded; peridia low, margin somewhat revolute, erose; aecidiospores globoid, 16–22 by 18–26 μ, wall rather thin, 2 μ, colorless, minutely verrucose.

The teleutospores used in the cultures were all of the normal two-celled form. The original collection on which the name was based does not appear to differ in any appreciable way from the usual two-celled form except in the many-celled teleutospores, which appear to be variations not uncommon in many grass species. The hosts of all three collections used in the cultures were of the form often made a distinct species under the name *Bromus purgans* L., which differs but slightly, chiefly in pubescence, from the typical *B. ciliatus.*

3. PUCCINIA STIPAE Arth. — On May 9, 1903, I found at Spirit Lake, Iowa, spermogonia and young aecidia on leaves near the ground of *Aster multiflorus,* with germinated teleutospores on old leaves of *Stipa spartea* within a few feet, and no other grass or sedge rust noticeable for a considerable distance

about. I was unable to secure material to carry forward this suggestive observation until the season following. Teleutosporic material was obtained at Spirit Lake, Iowa, and on May 9, 1904, was sown on *Aster ericoides,* which gave very abundant spermogonia on May 18, and strong aecidia on May 27. A second sowing was made on May 13 and another on May 21, which gave marked results with *Aster multiflorus* and *A. Novae-Angliae,* but no infection with *A. cordifolius, A. Drummondii, A. paniculatus* and *A. sericeus,* although the host plants were in vigorous growing condition. The data for these sowings are as follows:

May 9, Teleutospores sown on *Aster ericoides;* May 18, spermogonia; May 27, aecidia.
May 13, Teleutospores sown on *Aster multiflorus;* May 23, spermogonia; May 28, aecidia.
May 13, Teleutospores sown on *Aster cordifolius;* no infection.
May 21, Teleutospores sown on *Aster multiflorus;* May 29, spermogonia; June 4, aecidia.
May 21, Teleutospores sown on *Aster Novae Angliae;* May 27, spermogonia; June 3, aecidia.
May 21, Teleutospores sown on *Aster Drummondii;* no infection.
May 21, Teleutospores sown on *Aster paniculatus;* no infection.
May 21, Teleutospores sown on *Aster sericeus;* no infection.

The spermogonia and aecidia of this species are wholly unlike those of the common *Carex* rust, both in general appearance and microscopic characters. The leaves of the host are thickened and more or less distorted by the fungus, and the aecidia have the pustular appearance of *AE. recedens* on *Solidago, AE. hemisphericum* on *Lactuca,* and other Composite-species having very delicate peridia, or none. The spores instead of being a bright orange-yellow, as in most aecidia, are decidedly brown. It is a very distinctive form, and yet I have been unable to learn of but one collection having been made, beside my own. It was found on *Aster multiflorus,* Bourbon Co., Kans., May 29, 1902, by A. O. Garrett, who kindly sent me a specimen.

Finding the aecidium of *Puccinia Stipae* shows that the American species is wholly distinct from the European species on Stipa, which Bubak has proven by cultures belongs to an aecidium on the Labiate-genus *Thymus.* The aecidium does not attack all species of *Aster* alike, but judging from present cultural results, can be expected on the suffrutescent forms having coarse narrow leaves of firm texture. Such species may represent a natural group within the genus, but if so the taxonomists have not defined it. It is somewhat more probable that they represent an ecological group adapted to a dry atmosphere. The aecidium has not been characterized, and therefore a description is appended.

PUCCINIA STIPAE Arth.

0. Spermogonia amphigenous, irregularly grouped, punctiform, brownish orange, subepidermal, globoid, 95–110 µ in diameter; ostiolar filaments free, 35-50 µ long.

I. Aecidia amphigenous, in irregular groups, on hypertrophied spots, brownish orange, small; peridia low, fragile and evanescent, cells abutted or slightly imbricated, smooth outside, tuberculate inside, thin walled; aecidiospores globose, 18–25 µ in diameter, wall medium thick, 1–2 µ, brownish yellow, closely and finely verrucose, pores many, scattered, often conspicuous.

On *Aster multiflorus* Ait., Iowa and Kansas, and also cultivated on *A. ericoides* L., and *A. Novae-Angliae* L.

4. PUCCINIA SORGHI Schw.— Through a fortunate observation in the field, June 2, 1904, upon finding aecidia on *Oxalis cymosa* Small, the attempt was made to grow the aecidiospores on young corn plants, which resulted in complete success. On June 2, aecidia-bearing leaves were suspended over potted corn plants, under a large bell jar. On June 10 uredosori broke through the epidermis, and on July 10 teleutosori began to appear. This is taken as demonstrating the genetic connection of *Æcidium Oxalidis* Thuem. and *Puccinia Sorghi* Schw.

A detailed account of this culture, with citation of all collections of the aecidium on various species of *Oxalis,* known to the writer, has already been published in the Botanical Gazette (38:64-67. 1904).

5. PUCCINIA PODOPHYLLI SCHW.—This autoecious species of rust is very common in the vicinity of Lafayete, Ind. Leaves bearing recently opened aecidia were placed above the leaves of two potted plants on May 7, and both kept under bell-jars for three days. On May 23, one plant began to show teleutospores, and, on May 20, the other plant exhibited many whitish spots which began to burst open and display teleutospores on May 24. Both plants proved to be heavily infected over large areas of the leaves.

The principal interest in this culture comes from the fact that the sowing of aecidiospores did not give rise to secondary aecidia, but exclusively to the characteristic teleutospores. Sydow in his Monog. Uredinearum (1:526) states that this species has primary and secondary aecidia, the former being more common and forming extended groups, the latter coming later with the teleutospores and are sparsely distributed with few together in small groups. As many similar species of rusts have repeating aecidia, it would be natural to suppose that in this case the secondary generation arose from the aecidiospores of the first generation. The culture was made from a luxuriant development of the primary form; and from the fact that no secondary aecidia appeared, I think it can be safely assumed, that the so-called secondary generation arises, generally at least, from teleutospores, and its sparse distribution is due to the smaller number of sporidia which strike the leaf, or to the inhibition of maturer tissues in the leaf. So far as this culture can be taken as evidence, it shows that a true secondary generation of the aecidium probably does not occur in *P. Podophylli.*

SUMMARY.

The following is a complete list of successful cultures made during the season of 1904. It is divided into the two series: species previously reported by the writer or other investigators, and species now reported for the first time.

A. Species previously reported.

1. MELAMPSORA MEDUSAE Thuem.—Teleutospores from *Populus deltoides* Marsh. and *P. tremuloides* Michx. sown on *Larix decidua* Mill., and from *P. deltoides* Marsh. sown on *L. laricina* (Du R.) Koch.

2. PHRAGMIDIUM SPECIOSUM Fr.—Teleutospores from *Rosa Arkansana* Port. sown on *R. Arkansana* Port., *R. humilis* Marsh., *R. Carolina* L., and *R. nitida* Willd.

3. PUCCINIA HELIANTHI Schw.—Teleutospores from *Helianthus mollis* Lam. sown on *H. annuus* L. and *H. mollis* Lam. with abundant infection, and on *H. hirsutus* Raf., *H. occidentalis* Ridd., *H. strumosus* L., and *H. tomentosus* Michx. with slight infection; from *H. grosse-serratus* Mart. sown on *H. annuus* L., and *H. grosse-serratus* Mart. with abundant infection, and on *H. tomentosus* Michx. with slight infection; and from *H. laetiflorus* Pers. sown on *H. annuus* L., *H. laetiflorus* Pers., and *H. scaberrimus* Ell. with abundant infection, and on *H. divaricatus* L., *H. Kellermani* Britton, *H. mollis* Lam., *H. occidentalis* Ridd., and *H. tomentosus* Michx. with slight infection.

4. PUCCINIA SUBNITENS Diet.—Teleutospores from *Distichlis spicata* (L.) Greene were sown on *Chenopodium album* L., *Cleome spinosa* L., *Lepidium apetalum* Willd., *L. Virginicum* L., *Sophia incisa* (Engelm.) Greene, and *Erysimum asperum* DC.

5. PUCCINIA PAMMELII (Trel.) Arth.—Teleutospores from *Panicum virgatum* L., sown on *Euphorbia corollata* L.

6. PUCCINIA VERBENICOLA (E. & K.) Arth.—Teleutospores from *Sporobolus longifolius* (Torr.) Wood sown on *Verbena urticaefolia* L.

7. PUCCINIA WINDSORIAE Schw.—Teleutospores on *Tricuspis seslerioides* Torr. sown on *Ptelea trifoliata* L.

8. PUCCINIA FRAXINATA (Schw.) Arth.—Teleutospores on *Spartina cynosuroides* Willd. sown on *Fraxinus lanceolata* Borck.

9. PUCCINIA IMPATIENTIS (Schw.) Arth.—Teleutospores on *Elymus Virginicus* L. sown on *Impatiens aurea* Muhl.

10. PUCCINIA POCULIFORMIS (Jacq.) Wettst.— Teleutospores on *Elymus Canadensis* L., *Agropyron tenerum* Vasey and *A. repens* (L.) Beauv. sown on *Berberis vulgaris* L.

11. PUCCINIA RHAMNI (Pers.) Wettst.— Æcidiospores on *Rhamnus lanceolata* Pursh. *R. Caroliniana* Walt., and *R. Cathartica* L., sown on *Avena sativa* L.

12. PUCCINIA ANGUSTATA Peck.— Teleutospores on *Scirpus atrovirens* Muhl. sown on *Lycopus Americanus* Muhl.

13. PUCCINIA PECKII (DeT.) Kellerm.— Teleutospores on *Carex lanuginosa* Michx., and *C. trichocarpa* Muhl. sown on *Onagra biennis* (L.) Scop.

14. PUCCINIA CARICIS-ERIGERONTIS Arth.— Teleutospores on *Carex festucacea* Willd. sown on *Erigeron annuus* (L.) Pers.

15. PUCCINIA ALBIPERIDIA Arth.— Teleutospores on *Carex gracillima* Schw. sown on *Ribes Uva-crispa* L., *R. Cynosbati* L., and *R. rotundifolium* Michx., with a slight infection on *R. aureum* Pursh; and on *C. crinita* Lam. sown on *R. Uva-crispa* L. and *R. rotundifolium* Michx.

16. PUCCINIA POLYGONI-AMPHIBII Pers.— Æcidiospores on *Geranium maculatum* L. sown on *Polygonum emersum* (Michx.) Britt.

B. Species reported now for the first time.

1. MELAMPSORA BIGELOWII Thüm. — Teleutospores on *Salix amygdaloides* Anders. sown on *Larix decidua* Mill.

2. PUCCINIA TOMIPARA Trel.— Teleutospores on *Bromus ciliatus* L. sown on *Clematis Virginiana* L.

3. PUCCINIA STIPAE Arth.— Teleutospores on *Stipa spartea* Trin. sown on *Aster multiflorus* Ait., *A. ericoides* L., and *A. Novae-Angliae* L.

4. PUCCINIA SORGHI Schw.—Æcidiospores on *Oxalis cymosa* Small sown on *Zea Mays* L.

5. PUCCINIA PODOPHYLLI Schw.—Æcidiospores on *Podophyllum peltatum* L. sown on same host.

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